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Testing a tool to support safety in healthcare facility design

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Abstract

A Safety Risk Assessment is included in the 2014 Faculty Guidelines Institute (FGI) *Guidelines for the Design and Construction of Hospitals and Outpatient Facilities*, however, tools to support this requirement do not exist. This paper presents continued development of a Safety Risk Assessment (SRA) toolkit to be used proactively during the design of healthcare facility projects. Following content development, the tool was tested at three project sites and through hypothetical scenarios in an interactive testing process engaging expert panels. The testing revealed tactical considerations (content clarity, redundancy, etc.) and strategic aspects (themes related to use) for finalizing the tool.

Keywords: Paient safety; Health facility environment; Environment design; Risk management; Human factors ergonomics

1. Introduction

Improving safety is one of the most urgent issues facing healthcare. There has been an increasing focus on reducing adverse outcomes [1-5] and a growing awareness that the built environment plays a role in mitigating these conditions [6-11]. As one key component of the healthcare system, the physical environment interacts with other factors (e.g. organizational culture, operation) in complex ways impacting the risks of adverse events. While there is research surrounding the development of clinically-based safety protocols (e.g. surgical checklists), there is a paucity of published research that details the development of design tools used in healthcare facility design. This

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paper presents continued development of a Safety Risk Assessment (SRA) toolkit to be used proactively during the design of healthcare facility projects. As previously reported by Taylor et al. [12], the SRA tool has been developed using a consensus-based methodology with six expert workgroups. Following content development, the tool has now been tested at three project sites and through several hypothetical scenarios in an interactive testing process engaging expert panels. The study took a convergent mixed methods approach.

2. Methods

2.1. Testing the SRA using scenarios

Scenarios can help prompt the decisions made during design and establish participant communication [13]. However, the term scenario suffers from a lack of definition [14]. In this project, the scenarios were neither intended as "horizon planning" or methodological tools for decision making by creating multiple futures for discussion [14, 15], nor to understand the specific tasks and work processes that should be supported [16, 17]. Rather, as in some human computer interaction studies, the scenarios were used as a starting point for seminar activities, where it was left to the participants to decide how and how much to use the scenarios [13]. The seminar site used for testing was Kaiser Permanente's (KP) Garfield Center for Innovation, described by KP as a living laboratory. The Garfield Center has several existing mockup spaces, such as patient rooms, an operating room, nursing stations, and outpatient clinics.

For scenario testing the SRA, three setting types were envisioned for teams to use as part of the process. These included a meeting format, a low-fidelity mock-up (a room constructed of plywood with cardboard components [e.g. hand wash sink] and some furniture and equipment), and a high fidelity mock-up (rooms including final finishes, furniture, equipment, and non-functioning fixtures [e.g. sink, toilet]). The meeting format incorporated a unit renovation at a community hospital. The low-fidelity mock-up was an Emergency Department (ED) exam room, where groups were encouraged to move objects and adjust the layout in any way they felt better addressed the SRA content. The high-fidelity mockup scenarios used two existing patient rooms: an older version of a prior KP standard and a newer Labor and Delivery suite (LDR). Due to the differences in the available high-fidelity spaces, two scenarios were developed, one for each room type. The older room standard incorporated a scenario of a short-term oncology unit renovation. Teams were provided with a unit plan and instructed to consider safety-specific modifications that could serve as interim solutions while a new project was being designed. The LDR room was used as a hypothetical benchmarking visit – allowing a design team to consider options they might want to incorporate into their own project.

Plans were included as part of the evaluation package and demographic data were assembled from publicly available census records or town/city reports. The considerations were printed on large format sheets (24" x 36") and clipped to easels for the group to record their own notes. The content was not provided in advance of the sessions, but was the same for each of the group's modules (i.e. the same falls and patient handling considerations were reviewed for each module and scenario).

2.2. SRA testing using pilot site projects

Additionally, projects were sought in in varied regions of the US and in different stages of the design process - block diagrams, schematic design and design development. An opportunistic sample was selected: Barnes Jewish Hospital (BJH) in St. Louis, MO; the University of California Irvine Medical Center (UCI) in Irvine, CA; and the Memorial Sloan Kettering Cancer Center (MSK) in New York, NY. Each used an oncology project to test the tool – one new construction and two renovations. One pilot site test was conducted prior to scenario testing, and two were conducted after the extensive feedback from the expert workgroups. Each pilot test included modifications based on prior test feedback.

2.3. Test participants

All subject matter experts from Year 1 content development (criterion sample) were invited to participate in the Year 2 interactive testing seminar. Sixty-two percent of the Year 1 seminar participants returned. Additional recruits (a convenience sample) included architects and designers who specialize in healthcare facility design, a category that had fewer participants in Year 1, due to the nature of the content development expertise. Subject matter teams made up of up to eight experts were combined to address areas with the most overlapping interest (i.e. falls and patient handling; security and psychiatric/behavioral health injury). At the pilot sites, there was a range of participant expertise, some specific to one of the risk categories (e.g. pharmacists/nursing for medication safety, epidemiologists for infection control). Selection was left to the pilot test organization, but suggestions for the types of people that might be engaged were provided.

2.3.1. Data collection

Scenario testing started with an orientation, followed by a series of test sessions where participants used the tool in the hypothetical scenario. All teams started with the meeting format (Module A), and completed the high-fidelity (Module B) and low-fidelity (Module C) testing, as well as a module for considering dissemination (Module D), and an overall team debrief before concluding the event (Table 1). The order varied by topic, due to space limitations.

Table 1. Testing sequence in varied scenario modules.

Team	SRA components/topics	Session 1	Session 2	Session 3	Session 4	Session 5
1	Falls/ Patient Handling (F/PH)	Module A	Module B	Module D	Module C	Debrief
2	Falls/ Patient Handling (F/PH)	A	B	D	C	Debrief
3	Psychiatric ((Behavioral Health) Injury/Security (BH/Sec)	A	C	B	D	Debrief
4	Psychiatric ((Behavioral Health) Injury/Security (BH/Sec)	A	C	B	D	Debrief
5	Healthcare-associated Infection/ Med Safety (HAI/MS)	A	D	C	B	Debrief
6	Healthcare-associated Infection/ Med Safety (HAI/MS)	A	D	C	B	Debrief

Each group focused on the same two assigned SRA components throughout the seminar to help evaluate usage of same tool within different design conditions and scenarios. The workgroup teams were instructed to complete as many considerations as possible in each topic area in approximately 35 minutes. Returning participants were familiar with the content developed in the prior year, and all groups completed all considerations in all scenarios.

At the pilot sites, each session included an orientation to the SRA project (remote or live), followed by testing where participants used the tool for their project. Unlike the scenario testing with the expert workgroup teams, the pilot sites did not complete all topic areas or even all of the content in their selected categories. As the first test site, the BJH team decided to allocate 20 minutes per section in order to complete as many of the topics as possible. This was feasible given the project phase (design development) where fewer decisions could be made and the tool became more of a validation instrument. With the other pilot sites earlier in the design process, additional time for discussion was needed. Topics and completion rates for the pilot sites are summarized in Table 2.

Table 2. Summary of Pilot Site Considerations (Completion and Time).

Site and Design Phase	UCI (Master Planning): n=13	MSK (Schematic Design): n=15	BJH (Design Development): n=4 FT, 3 PT
Topics covered and completion rate	HAI (60% complete); Medication safety (60% complete)	Falls (47% complete); Infection control (66% complete); Medication safety (61% complete)	Falls; Infection control; Patient handling; Security (43% complete); Medication safety (86% complete)
Scheduled time for tool use	3 hours	2.75 hours	1.75 hours
Average time/ consideration	4 minutes	3 minutes	1 minute
Time range for considerations	10 sec – 15 min	20 sec – 8 min	10 sec – 3 min

UCI, the second pilot site, was the first test following the two-day Year 2 testing seminar, and some of the duplications and clarity were addressed prior to their “live” session. In addition, similar considerations were grouped, based upon feedback from testing with the hypothetical scenarios. The last pilot site (MSK) was facilitated

by a researcher (ET), based upon feedback from the prior pilot tests. Topics were integrated and the testing order was organized by levels of building design decision-making (e.g. unit layout, room layout).

3. Results

3.1. Qualitative analysis

As part of a PhD thesis, qualitative coding was undertaken following the process of Miles et al. [18] and Corbin and Strauss [19]. These were categorized according to a previously reported literature review [12]: design culture (existing processes and users and design); the evidence base (using, managing, and sharing knowledge); and guidance needs. The focus of this paper is on the guidance needs specific to the tool.

3.1.1. Guidance needs

Guidance needs most often centered on optimizing use of the tool, both tactical and strategic. The tactical considerations for improving the tool following scenario testing included eliminating content redundancy, reviewing the item order, and clarifying the rationale. Workgroup members provided specific suggestions including.

- Other factors such as cultural issues and operational processes often impact safety. It might be helpful to provide a guide around the process including: the composition of SRA team (.g. subject-matter experts) and individuals' responsibilities; the engagement of external facilitation services; connection to cultural and operational issues, especially other existing safety processes; the required information to serve as input to the SRA (such as risk evaluation); and how to address potential conflicts/trade-offs between components, etc.
- The decision on adopting a design consideration would depend on an estimation of value versus cost as well as its relative priority among all considerations.
- Design considerations addressing similar or closely relevant issues (e.g. design disciplines such as mechanical design) should be grouped together to make the tool easier to use.
- For a specific project (e.g. the scenarios covering specific patient types), some design considerations might be irrelevant (i.e. N/A-not applicable). It would be ideal to be able to filter "N/A" considerations to avoid fatigue.
- The results of the SRA might be the relative priority levels (e.g. high, medium, low) of design considerations instead of simple yes-no-maybe answers.
- The rationale statements were useful but need revisions to further strengthen and clarify (e.g. references).
- Simulated environment (i.e. mock-ups) helped to visualize spaces and could facilitate communication.
- Definitions were needed for some terms especially for those not familiar with the subject. Some terminology might be considered outdated.
- The tool would be helpful as a check-in across design phases.

In addition, many testers commented that the SRA process could be a way to identify strategic priorities for the organization. This in turn, would act as a filter for decision-making and inform any "value engineering" stage. In suggestions for streamlining the process, the groups also referenced the need for an information hierarchy as a filter. For example, addressing the need for patient handling at an early phase (a macro issue), while considering grab bars at a later phase (a micro issue). However, there was also an awareness of the need to balance a discussion of more detailed information that is often not considered until later in the process, when there is a negative budget implication.

3.2. Survey results and comparisons

Each group (scenario workgroups or pilot test participants) were given a Likert-scale survey following each use of the SRA tool, for example, after each scenario module, or after the pilot test. The 5-point scale ranged from "1: Strongly Disagree" to "5: Strongly Agree." During the scenario testing, this survey was conducted online prior to the verbal debrief. During the pilot tests, the participants completed a paper-based survey prior to the focus group debrief. Six questions were common to all participants testing the SRA tool in scenarios and project tests.

Comparisons were made according to: each group that tested the SRA (i.e. six workgroups and three pilot sites); and combined setting types (three module types for scenarios and the pilot sites combined as "real world" module).

Quantitative analysis using SPSS 22.0 [20] included descriptive statistics, tests for normality, and comparison of means, to evaluate whether there were similarities or differences in self-evaluated perceptions of using the tool. Because Shapiro Wilks tests for normality were violated in nearly all cases, comparing means by one-way analysis of variance (ANOVA) was inappropriate. As a result, probability distributions of data were compared with non-parametric tests for independent samples (Kruskal-Wallis H test) for the following:

- H_0: The probability distribution of the survey responses are the same across workgroups, pilots, or modules.
- Ha: At least two of the workgroups (pilots/modules) have probability distributions of survey responses that differ.

An alpha level of .05 was used for all statistical testing. Post hoc analysis was conducted for statistically significant results. To control for experimental type-1 error (the probability of rejecting at least one pair hypothesis given all pairwise hypotheses are true), SPSS NPTESTS procedures adjust the p-values calculated and used for pairwise decisions. These are adjusted as p_{adj}= pK(K-1)/2 using ranks based on considering all samples rather than just the two involved in a given comparison, as proposed for Kruskal-Wallis (K-W) testing in 1964 by Dunn [21].

3.2.1. Enough Time

The K-W test for "Enough Time" between the teams was significant $\chi 2$ (8, N = 137) = 23.038, p = .003, with a mean rank score for Team 1 (F/PH), 76.83, for Team 2 (F/PH), 82.42 for Team 3 (BH/Sec), 60.87 for Team 4 (BH/Sec), 84.10 for Team 5 (HAI/MS), and 65.76, for Team 6 (HAI/MS), 66.03, for BJH, 45.00, for UCI, 37.42, and for MSK, 85.82. The proportion of variability in the ranked "Enough Time" scores accounted for 43.6 percent, indicating a moderately strong relationship. Post hoc tests to evaluate pairwise differences among the teams indicated a significant difference between UCI and Team 2 (F/PH), p_{adj} =.042, UCI to 4: BH/Sec, p_{adj} =.018, and UCI to MSK, p_{adj} =.000. There was also a significant difference between Team 3 (BH/Sec) and MSK, p_{adj} =.014. There were no other significant differences between the other team combinations.

The K-W test for "Enough Time" between settings was significant $\chi 2$ (3, N = 137) = 11.506, p = .009, with a mean rank score for A: Meeting, 60.01; B: High-fidelity, 83.82; C: Low-fidelity, 73.89, and Pilots, 59.33. The proportion of variability in the ranked "Enough Time" scores accounted for 70.8 percent, indicating a strong relationship. Post hoc tests to evaluate pairwise differences among the settings indicated a significant difference between B: High-fidelity and Pilots, p_{adj} =.028 and A: Meeting to B: High-fidelity, p_{adj} =.026. There were no other significant differences between the other setting combinations.

3.2.2. Guidance (through facilitation)

The K-W test for "Guidance (facilitation)" between the teams was significant $\chi 2$ (8, N = 137) = 36.208, p = .000, with a mean rank score for Team 1 (F/PH), 59.50, for Team 2 (F/PH), 46.81 for Team 3 (BH/Sec), 84.30 for Team 4 (BH/Sec), 57.23 for Team 5 (HAI/MS), and 60.27, for Team 6 (HAI/MS), 63.17, for BJH, 47.67, for UCI, 91.85, and for MSK, 109.21. The proportion of variability in the ranked "Guidance (person)" scores accounted for 42.9 percent, indicating a moderately strong relationship. Post hoc tests were conducted to evaluate pairwise differences among the teams. Results indicated statistically significant differences between 1 (F/PH) to MSK, p_{adj} = .003; 2 (F/PH) and MSK, p_{adj} = .000; 4 BH/Sec) to MSK, p_{adj} = .005; 5 (HAI/MS) to MSK, p_{adj} = .003, and 6 (HAI/MS) to MSK, p_{adj} = .015; and BJH and MSK, p_{adj} = .020. (MSK was the only team that participated in a facilitated format.) There were no other significant differences between teams.

The K-W test for "Guidance (facilitation)" between settings was significant $\chi 2$ (3, N = 137) = 18.553, p = .000, with a mean rank score of 63.33 for A; Meeting; 54.35 for B: High-fidelity; 68.42 for C: Low-fidelity; and 91.18 for Pilots. The proportion of variability in the ranked "Guidance (facilitation)" scores accounted for 59.6 percent, indicating a strong relationship. Post hoc tests were conducted to evaluate pairwise differences among the pilot sites. Results indicated statistically significant differences between both B: high-fidelity and Pilots, p_{adj} = .000 and A: Meeting and Pilots, p_{adj} = .008. There were no other significant differences between settings.

3.2.3. Guidance (content/rationale)

The K-W test for "Guidance (content/rationale)" between the settings was significant $\chi 2$ (3, N = 136) = 9.984, p = .019, with a mean rank score of 57.81 for A: Meeting, 71.63 for B: High-fidelity, 62.94 for C: low-fidelity, and 84.26 for Pilots. The proportion of variability in the ranked "Guidance (content/rationale)" scores accounted for 68.6 percent, indicating a strong relationship. Post hoc tests to evaluate pairwise differences among the settings indicated a significant difference between A; Meeting and Pilots, p_{adj} =.017. There were no other significant differences between the setting combinations.

The K-W test for "Guidance (content/rationale)" between the teams was significant $\chi 2$ (8, N = 136) = 39.379, p = .000, with a mean rank score Team 1 (F/PH), 69.19, for Team 2 (F/PH), 29.35 for Team 3 (BH/Sec), 40.07 for Team 4 (BH/Sec), 75.97 for Team 5 (HAI/MS), and 78.11, for Team 6 (HAI/MS), 74.24, for BJH, 60.08, for UCI, 75.73, and for MSK, 105.58. The proportion of variability in the ranked "Guidance (content/rationale)" scores accounted for 27.8 percent, indicating a moderate relationship. Post hoc tests were conducted to evaluate pairwise differences among the teams. Results indicated statistically significant differences between 2 (F/PH) and 5 (HAI/MS), p_{adj} = .005; 2 (F/PH) and 6 (HAI/MS), p_{adj} = .025; 2 and UCI, p_{adj} = .046; 2 to MSK, p_{adj} = .000; and 2 to 4 (BH/Sec), padj = .029. There was also a significant difference between 3 (BH/Sec) and MSK, p_{adj} = .000. There were no other significant differences between teams.

3.2.4. Easy to Use

The K-W test for "Easy to Use" between the settings was significant $\chi 2$ (3, N = 136) = 10.256, p = .017, with a mean rank score of 56.88 for A: Meeting; 81.96 for B: High-fidelity; 63.73 for C: Low-fidelity; and 72.79 for Pilots. The proportion of variability in the ranked "Easy to Use" scores accounted for 69.4 percent, indicating a strong relationship. Post hoc tests were conducted to evaluate pairwise differences among the pilots. Statistically significant results were only found between A: Meeting and B: High-fidelity, p_{adj} = .014. There were no differences between the other combinations of settings.

4. Discussion

Overall, the testing of the SRA reveals significant opportunity for a proactive process that focuses on safety to positively affect the way healthcare facility design is approached. The process offers a decision-making forum that balances needs and priorities and provides an opportunity for stakeholders to learn from each other's perspectives. The use of knowledge is enhanced through the participation of experts and users who can challenge assumptions, share real-world experiences, and synthesize the types of information brought to the discussion. There were few differences in coding between topics and settings, but there was significant variation by team, even within topic. Team composition (expertise and personality) must be considered to facilitate dialogue that informs the design process. At a high level, there can be some generalizations between the qualitative coding and the quantitative analysis for topics, teams, and settings.

4.1. Topics

Established topics (such as infection control) may initially fare better in safety-focused discussions. Areas of infection control and medication safety each have more of an evidence base in the form of available research, while security and psychiatric injury have much less published research and are more reliant on accepted guidelines. The evidence for falls lies in the middle, as the complexity of confounders and bundles of interventions can lead to a less than clear direction on optimum solutions.

While this could not be compared specifically through the quantitative data, as topics were integrated during testing, it is interesting to note that there were statistically significant differences when comparing self-scoring for guidance through content and rationale by integrated topic. During scenario testing, Falls/Patient Handling were generally lower as compared to Infection (HAI)/Medication Safety. This may be due, in part, to a higher level of familiarity of working with infection preventionists, as infection control has been included in the FGI *Guidelines* since 1996. Pharmacists have also been made increasingly aware of the influence of interruptions, distractions, noise and lighting on medication error as a result of the 2010 United States Pharmacopeial Convention's National

Formulary, *Chapter 1066: Physical Environments that Promote Safe Medication Use*. This difference may also be partially attributed to the use of tacit and explicit knowledge, where infection control and medication safety have made strides in explicit translation of the built environment issues through codes and guidelines, as compared to falls, which may have more reliance on the tacit knowledge of individual experiences.

Testing indicated that there is integration of safety topics that can occur as part of the process. This is important to understand the tradeoffs that may need to be considered through the perspective of different safety topics, as well as the ability to develop solutions that may simultaneously address more than one problem.

4.2. Settings

Quantitative analysis indicates that settings influence the perceived time to complete the SRA process. This was exhibited in the scenarios (less perceived time in Module A; Meeting as compared to Module B: High-fidelity), as well as in the combined results (less perceived time in Module A; Meeting as compared to Module B: High-fidelity and less perceived time in the pilots as compared to B: High-fidelity). Statistically significant differences indicated the ease of use during scenario testing was also perceived as better in Module B: High-fidelity setting as compared to Module A: meeting. The potential perception that there was "less to decide" in the two high-fidelity mockups may have influenced the evaluation of time and ease of use. It was evident from observing different phases at the pilot sites, that there are limited conversations once a decision has been made. With each increasing round of what may be perceived as a "finished" product (e.g. a professional rendering, a high-fidelity mockup), there is less need to question what was previously discussed.

4.3. Teams

The qualitative analysis indicated the benefit of multi-disciplinary of transdisciplinary teams. This is supported by the quantitative analysis of self-evaluation, in which there were statistically significant differences found between the teams in several categories. There were statistically significant differences between the teams in the perception of enough time for testing, but it was not consistent for any one team to another. For example, this difference was present between Teams 2 (F/PH), 4 (BH/Sec), MSK and UCI, as well as between Team 3 (BH/Sec) and MSK.

A consistent difference between teams occurred in the self-scoring for Guidance (content/rationale) (Team 2: Falls/Patient Handling self-scored lower than nearly every other team (3, 4, 5, 6, UCI, MSK). This may be an indicator that the quality of discussions will be based upon the individuals selected to participate, rather than a sole reliance on the information included in the tool itself. However, the process provides a systematic approach that could better enable informed discussions even if the group composition is suboptimal.

Lastly, there were statistically significant differences in Guidance (through facilitation), where MSK self-scored higher than nearly all other teams (1, 2, 4, 5, 6, BJH). MSK was the only fully facilitated site. Based upon observation and participation, having someone familiar with the content and intent has a significant effect on the ability to navigate the considerations. The caveat is that a facilitator needs to understand where an organic conversation is constructive to the process, rather than diverting the group.

5. Conclusion

For many, the SRA process offered a value proposition to not only improve the design, but foster a culture of safety within the organization and build consensus; however, the SRA will only be as effective as the effort put in. As one participant stated, *"Sometimes it's easier to meet the prescriptive, but miss the intent."* Leadership must promote/allow participation and participants must be interested and engaged to minimize a siloed and reactive approach.

The qualitative and quantitative analysis confirms that the SRA tool can be used in a variety of ways to focus teams on the issues of safety in healthcare facility design. As such, this toolkit may also serve to proactively advance HFE knowledge of "the environment of the environment" for HFE specialists that may be involved in health care facility design. As with many practices that become institutionalized, there is always a danger of misuse,

however, once fully developed and implemented, the tool will be a significant step forward in enhancing patient and staff safety through reducing adverse physical environment latent conditions that are built into facilities during the planning, design, and construction of healthcare facilities.

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